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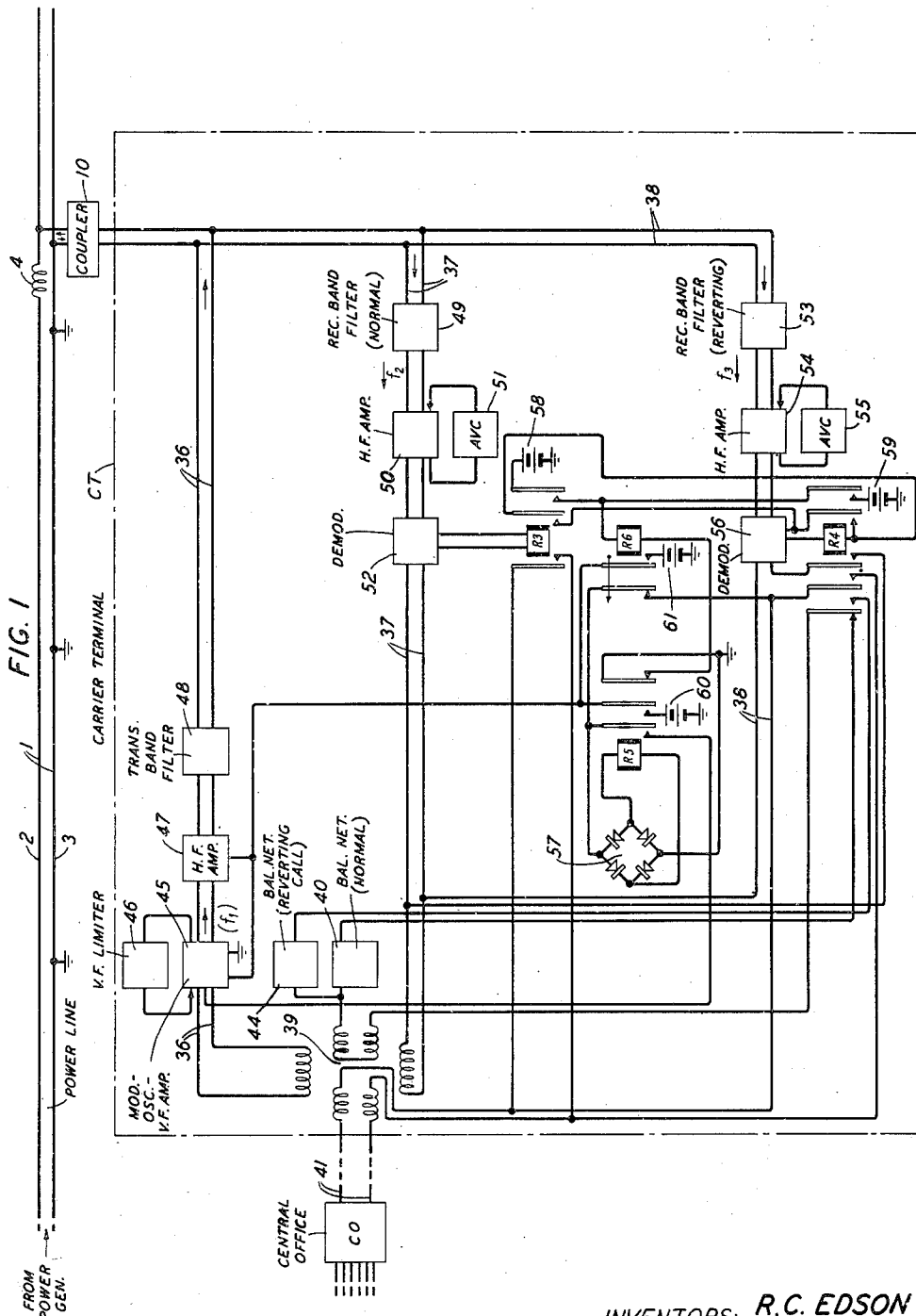
R. C. EDSON ET AL

2,481,915

POWER LINE CARRIER WAVE COMMUNICATION SYSTEM

Filed March 9, 1946

2 Sheets-Sheet 1



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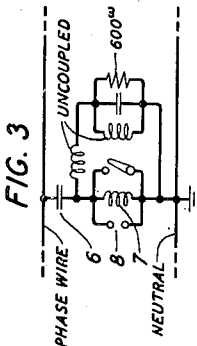
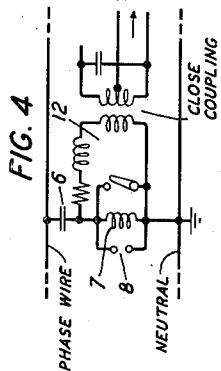
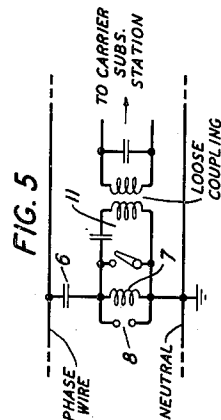
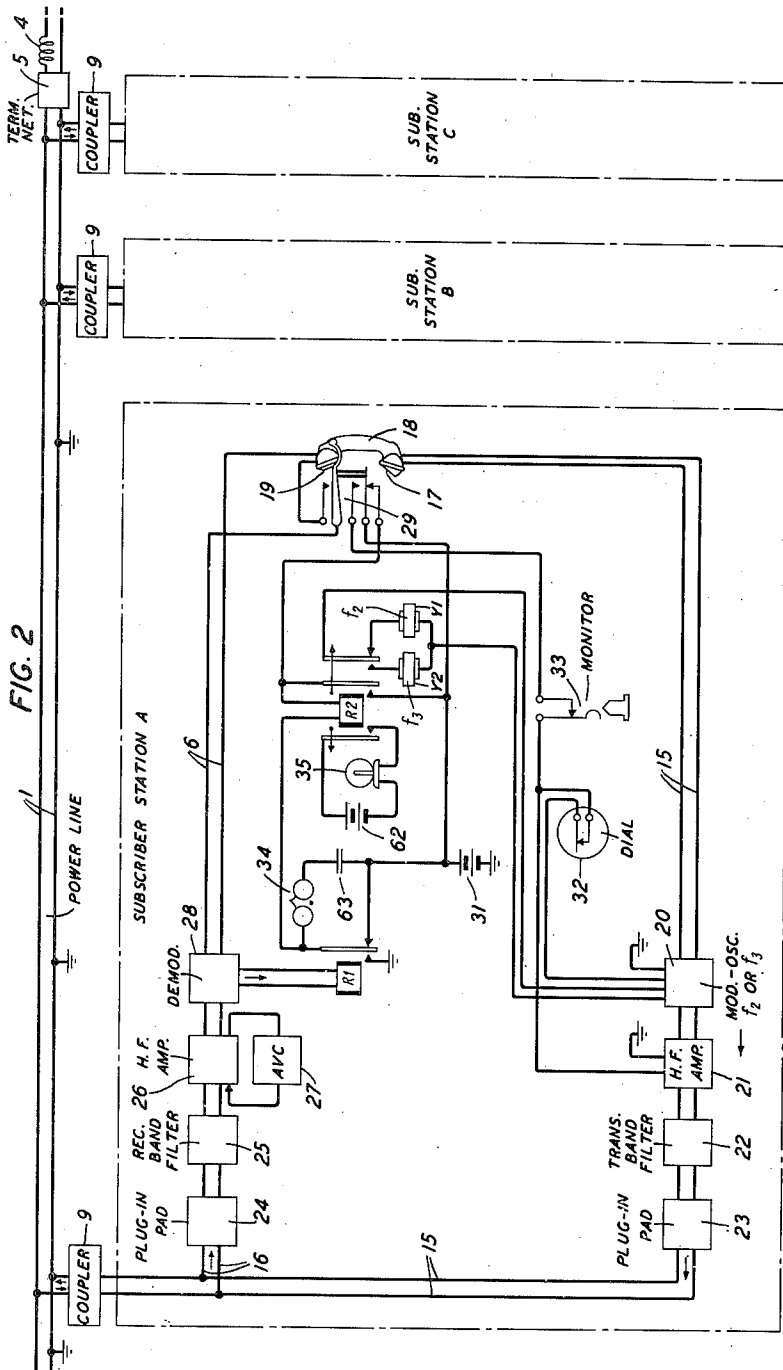
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POWER LINE CARRIER WAVE COMMUNICATION SYSTEM

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POWER LINE CARRIER WAVE COMMUNICATION SYSTEM

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8 Claims. (Cl. 179-2.5)

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The invention relates to an electric wave transmission system, and particularly to an electric wave communication system employing high frequency carrier waves for transmitting the communication signals.

The invention is applicable to a communication system employing one or more high frequency carrier channels to provide two-way telephone service to telephone subscribers over a common transmission medium. In such a system, the common medium may be a transmission line, for example, one used primarily for supplying low frequency, high voltage electric power to a number of power consumers in a power distribution network in a rural area, or it may comprise one or more wire and radio transmission links. Each carrier channel may be utilized for providing two-way communication between telephone subscribers associated with that channel on a party-line basis over the line or other common transmission medium through an individual carrier terminal having an associated central switching office which may be associated also with other carrier channels on the common medium. The central office may provide means for connecting the carrier telephone subscribers' stations associated with each carrier channel on the common transmission medium in communication relation with each other or with other telephone subscribers' stations associated with other carrier channels on the same medium or on outside systems.

The invention is specifically applicable to a carrier communication system of the general type described above in which three different high frequency electric waves per channel are employed as carriers for both signaling and speech transmission over the line or other common transmission medium, such as is disclosed in the copending patent application of M. L. Almquist, Serial No. 625,083, filed October 27, 1945. In such a system, transmission from the carrier terminal to the carrier telephone subscriber associated with a carrier channel on the line or other common transmission medium is always on one of these frequencies, say the frequency f_1 , and transmission from each subscriber's station on that carrier channel over the common medium to the central office carrier terminal is on either one of two other carrier frequencies, say frequency f_2 or f_3 , depending on the type of call. Voice frequency transmission is provided between the central office and the carrier terminal. On central office calls, that is, calls between a carrier subscriber associated with one carrier channel on the common medium and the central office, or an

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outside subscriber connected to that office, transmission from the carrier terminal to the carrier subscriber is on carrier frequency f_1 and from the carrier subscriber to the carrier terminal on carrier frequency f_2 . On reverting or party-line calls, that is, calls between two carrier subscribers on the same carrier channel on the common medium, a calling subscriber transmits to the carrier terminal on the carrier frequency f_3 , and receives from the carrier terminal on carrier frequency f_1 , and the called subscriber transmits to the carrier terminal on carrier frequency f_2 and receives from that terminal on carrier frequency f_1 , means being provided at each subscriber's station for shifting from the normal transmitting carrier frequency f_2 to the alternate transmitting carrier frequency f_3 when the subscriber at that station has initiated a reverting call. In the system of the aforementioned patent application this frequency shifting means is under control of the calling subscriber, a nonlocking key being provided in each carrier subscriber's set for this purpose.

An object of the invention is to improve a carrier signaling system of the general three-carrier frequency type described above, particularly from the standpoint of automatic operation on reverting calls.

Another object is to supply two-way carrier telephone service efficiently and economically over a common transmission medium, such as a power distribution line, to a number of telephone subscribers, for example, to individual power consumers served by the same power line in a rural area.

Other objects are to provide two-way communication between any two of a number of subscribers associated with the same carrier channel on a common transmission medium, on a party-line basis; to provide two-way communication between any subscriber associated with one carrier channel on the common medium and another subscriber on another carrier channel on the same medium or on an outside system over the common medium through a central office; and to provide a conference connection between any two subscribers on the same carrier channel on the common medium and any outside connection (voice or other carrier channel on the common medium) through the central office.

In accordance with the present invention, a three-frequency carrier communication system of the above-described general type is modified mainly to provide a different control arrangement and procedure for setting up reverting calls.

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In the modified system, the switching of the carrier frequencies at the calling subscriber's station required for a reverting call is indirectly controlled by the called subscriber on the same carrier channel, when the latter operates his hook switch in answer to a ringing signal sent out from the central office. The call is set up in the following manner: The calling subscriber by removing his handset from the switchhook causes his carrier transmitter to be energized so as to send out a carrier of the normal frequency f_2 over the common medium to the carrier terminal where it operates switching arrangements to bring in the operator or dialing equipment in the associated central office, and to energize the carrier transmitter at that terminal so that it sends the carrier frequency f_1 over the common medium to operate busy signaling devices at all subscriber stations. The calling subscriber then places his call with the central office by sending out his voice or dialing call signals on his normal transmitted carrier f_2 to the carrier terminal where they are demodulated to voice frequencies for transmission to the central office. The calling subscriber then hangs up, and the carrier f_1 modulated with coded low frequency (20-cycle) ringing current is sent out from the carrier terminal under control of the central office operator or machine switching equipment until the called subscriber answers and sends out his normal carrier frequency f_2 to energize the transmitter at the carrier terminal. The continuous carrier frequency f_1 then sent out over the line from the carrier terminal operates switching equipment at the calling subscriber's station to shift the tuning of the transmitter at the latter station from f_2 to f_3 . When ringing ceases, the calling subscriber lifts his telephone set from the switchhook to energize his transmitter which sends out the reverting carrier frequency f_3 , since the frequency f_1 initiated by the called subscriber was on the line prior to this operation of the calling subscriber's switchhook. The calling subscriber's talking signals are transmitted on carrier f_3 to the carrier terminal where they are demodulated to voice frequencies and remodulated on carrier f_1 for transmission over the line to the called subscriber. The called subscriber's talking signals are transmitted on the carrier f_2 to the carrier terminal and are there demodulated to voice frequencies and are remodulated on carrier f_1 for transmission over the line to the calling subscriber.

If a continuous carrier wave of the frequency f_1 is not present on the line when a subscriber operates his hook switch, the operation of the latter, in addition to energizing the transmitter at the station, also disables the switching equipment provided for shifting the transmitting carrier frequency so that the normal carrier of frequency f_2 is sent out.

These and other features of the system of the invention will be brought out in the following detailed description when read in conjunction with the accompanying drawing, in which:

Figs. 1 and 2, when placed side by side with Fig. 1 at the left, show in block schematic form a power line carrier telephone system embodying the invention.

Fig. 3 shows schematically one type of terminating network which may be used on the power line in the system of Figs. 1 and 2 to adapt it for carrier transmission;

Fig. 4 shows schematically one type of filter network which could be used for properly cou-

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pling the carrier terminal to the power line in the system of Figs. 1 and 2, and for providing in addition a suitable termination on the carrier terminal end of the power line; and

Fig. 5 shows schematically one type of filter which could be used for coupling each of the subscriber stations to the power line in the system of the invention shown in Figs. 1 and 2.

The power line carrier telephone system in accordance with the invention shown in Figs. 1 and 2 includes a transmission line 1 primarily employed for transmission and distribution of low frequency, high voltage electric power and adapted for simultaneous use for high frequency carrier wave telephony. The line 1 is shown as a single phase line consisting of one phase conductor 2 and a neutral conductor 3, the latter being grounded at a number of spaced points, for example, at each pole. This type of line is commonly used in rural areas for transmitting high voltage, low frequency (60-cycle) electric power to electric power consumers.

The portion of the power line 1 used for carrier transmission is isolated from the other portion of the line not so used by means of the carrier choke coils 4 connected in series with the phase wire 2 at the two ends of the carrier section, as indicated, these coils being designed to offer a high series impedance to the carrier frequencies so as to minimize adverse transmission effects from the portion of the power line not used for carrier transmission, but a low series impedance to the low frequency (60-cycle) power currents so as to enable the latter currents to be transmitted freely over the portion of the line used for carrier transmission to the power loads. Other suitable isolating or sectionalizing equipment may be employed in place of the choke coils, for example, filters or tuned circuits.

To prevent reflections which might make it difficult to detect the carrier frequency energy at various points in the line, it is desirable to terminate the ends of the portion of the line 1 employed for carrier transmission in approximately characteristic impedance at the carrier frequencies used; similarly, the ends of all branches (not shown) of the power line used for carrier transmission should be terminated in approximately characteristic impedance at the carrier frequencies used. The network 5 at the far end of the section of line 1 shown, for this purpose may be, for example, of the type illustrated schematically in Fig. 3. As shown in Fig. 3, it comprises a configuration of uncoupled inductances, condensers and a resistor forming a k -type half-section, band-pass filter network connected across the line, including a condenser 6 in one series arm, and a drainage impedance to ground which may be an inductance coil 7, as shown, or a resistor, shunted by a protective spark gap 8, connected in series with the condenser 6 between the phase wire and the grounded neutral conductor. The condenser 6, of value in the order of 2,000 micromicrofarads, serves as a high impedance to the high voltage (7.2 kilovolts), low frequency (60 cycles) power currents transmitted over the line 1, and the inductance 7 of value in the order of 10 millihenries, has a relatively high impedance over the carrier frequency band.

A plurality of like subscriber two-way carrier telephone stations A, B, C . . . associated with one carrier channel on the power line 1, that is, all transmitting on the same carrier frequencies and receiving on the same carrier frequency, are bridged across that line at different points by

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the coupler arrangements 9, and an individual two-way carrier terminal station CT for that carrier channel is bridged across the power line 1 at another point by the terminal coupler arrangement 10.

The subscriber coupler arrangements 9 may be of any suitable type, such as the type illustrated in Fig. 5, which like the terminating network of Fig. 3, includes a large coupling condenser 6, of value in the order of 1,000 to 2,000 micromicrofarads, in series with an inductance coil 7 shunted by a protective spark gap 8, connected in shunt with the phase wire and neutral wire of the power line. An impedance transformer, band-pass filter network 11 connects the subscriber's carrier telephone set across the inductance 7. The network 11 is designed to selectively transmit a narrow band of frequencies, for example, a band extending from 160 to 200 kilocycles, if the normal transmitting carrier frequency is 195 kilocycles, the reverting transmitting carrier frequency is 185 kilocycles and the receiving carrier frequency is 165 kilocycles, in each subscriber's carrier telephone set as in the system to be described; and also to prevent the low frequency power currents from entering the set. Network 11 is further designed to provide a moderately high impedance (say 1500 to 3000 ohms) on the power line side within its pass band and thus will cause only a small bridging loss on line 1. In addition, owing to the nature of a mid-series terminated band-pass filter such as shown, the impedance will be very high (and largely reactive) outside the pass band and thus will cause negligible bridging loss for all carrier channels except the one to which the associated subscriber set is assigned. If a subscriber station is at the end of the section of line 1, or branch thereof, used for carrier transmission, the network 11 may be connected to a terminating network of the type illustrated in Fig. 3 in place of the terminating resistor element of the latter.

The terminal coupler arrangement 10 also may be of any suitable type, such as the type illustrated in Fig. 4, which differs essentially from the subscriber coupler arrangement of Fig. 5 in that its impedance transformer, band-pass filter network 12 is designed to selectively transmit a wider frequency band (150 to 485 kilocycles) and to present an impedance on the line side suitable for terminating the carrier terminal end of the portion of power line 1 employed for carrier transmission in approximately characteristic impedance at the carrier frequencies used, so as to prevent reflections tending to make difficult the detection of the carrier frequency energy in carrier terminal CT. Thus, its use makes unnecessary the use of a separate line terminating network at the carrier terminal point such as is required at the other end of the portion of line 1 used for carrier transmission. The arrangement of Fig. 4, by passing the frequencies between 150 and 480 kilocycles, provides suitable coupling and termination for all carrier channels within this band of frequencies on the line 1, and thus avoids the necessity of using a plurality of different couplers at the terminal point when multichannel operation is provided.

Each of the subscriber stations A, B, C . . . , as shown at station A illustrated in block schematic form, comprises a transmitting circuit 15 and a receiving circuit 16. The transmitting circuit 15 includes in order, reading from right to left, a telephone transmitter 17 which may be combined in a standard hand telephone set 18 with

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the telephone receiver 19; a modulator and associated carrier oscillator for supplying to the modulator the carrier oscillations of the normal transmitting frequency f_2 (195 kilocycles) or the reverting transmitting carrier frequency f_3 (185 kilocycles), represented by the box 20 and the associated piezoelectric crystals Y1 and Y2 for respectively tuning the carrier oscillator to the normal carrier frequency f_2 (195 kilocycles) and the reverting carrier frequency f_3 (185 kilocycles); the high frequency amplifier 21; the transmitting band-pass filter 22; and the plug-in resistance equalizer pad 23 feeding into the line 1 through the coupler device 9. The high frequency receiving circuit 16 includes in order, reading from left to right, the plug-in resistance equalizer pad 24 fed from the line 1 through the coupler device 9; the receiving band-pass filter 25; the high frequency amplifier 26 which may comprise one or more vacuum tube stages with interstage and output filtering networks for tuning it to amplify properly the carrier signals over the frequency range transmitted by the preceding band filter, and an automatic volume control circuit 27 associated with the amplifier, which may be of any of the well known types, utilized for controlling the gain of the amplifier to compensate for variations in the amplitude level of the received carrier signals due to variations in the loss of the preceding section of line; the demodulator 28; and the telephone receiver 19 of the standard hand telephone set 18.

The modulator included within the box 20 in the transmitting circuit 15 may be of any suitable unbalanced type, including one or more electron discharge tubes or other variable resistance devices, adapted for combining high frequency carrier oscillations supplied to its carrier input terminals with audio frequency signals applied to its signal input terminals, so as to produce signal side-band components as well as the unmodulated carrier component in its output. The carrier oscillator in box 20 may also be of any suitable type, and may be combined with the associated modulator in a single electron discharge tube in conventional manner. The demodulator 28 in receiving circuit 16 may be of any suitable type, for example, it may comprise a varistor consisting of a plurality of copper oxide or crystal rectifier elements connected in series between the output of amplifier 26 and the telephone receiver 19. The transmitting band-pass filter 22 in the transmitting circuit 15 is designed to selectively transmit the voice signal-modulated carrier waves (one or more signal side-bands) of the high frequencies f_2 (195 kilocycles) and f_3 (185 kilocycles) which may be applied thereto from the output of the oscillator-modulator 20, as well as the unmodulated carrier frequency components of these frequencies; and the band-pass filter 25 in the receiving circuit 16 is designed to selectively transmit the voice signal-modulated carrier wave of the high frequency f_1 (165 kilocycles), as well as the unmodulated carrier of that frequency, received from the line 1.

Each of the subscriber's stations A, B, C . . . also includes the telephone hook switch 29 associated with the handset 18; a suitable power supply 31, such as a battery or rectified 60-cycle alternating current power source, adapted for connection through switching contacts on the hook switch 29, when the handset 18 is removed from the hook, to the modulator-oscillator 20 and the high frequency amplifier 21 in the transmitting circuit 15; a conventional calling dial 32 con-

ected in the power supply of the modulator-oscillator 20; and a normally closed monitor key 33 which may be opened by the subscriber to open the power supply circuit (from battery 31) to disable transmitting circuit 15 when he desires only to monitor (listen-in) on the transmission over the power line 1. Each of these stations also includes the electromagnetic switching relays R1 and R2 controlled from the output of the demodulator 28 in receiving circuit 16, and station signaling apparatus including a voice frequency ringer 34 and a busy signal lamp 35 controlled from these relays in a manner which will be described in detail later in connection with a description of the operation of the complete system.

The carrier terminal station CT comprises a transmitting circuit 36 and two receiving circuits 37 and 38. The output of the transmitting circuit 36 and the inputs of the two receiving circuits 37 and 38 are connected in parallel with each other and through the common coupler device 10 to the power line 1. The input of the transmitting circuit 36 and the outputs of the two receiving circuits 37 and 38 are adapted for connection by means of the hybrid coil 39 and associated normal line balancing network 40 to the two-wire voice frequency line 41 leading to the central telephone switching office CO for the subscriber stations on the power line. The central office CO, which may be of the manual or automatic type, may be utilized also for connecting the telephone subscriber stations on the power line 1 to any of the telephone subscriber stations outside the carrier system in an associated telephone network. The central office CO is normally disconnected from the carrier terminal station CT due to the normal break in the line 41 provided through parallel connected, normally open switching contacts on the control switching relays R3 and R4, respectively. The operation of either of these relays to close its contacts will enable the line 41 in its output so that the central office CO will be connected in transmission relation with the carrier terminal CT through the hybrid coil 39. An alternate line balancing network 44 is adapted to be connected to the network terminal of the hybrid coil 39 in place of the normal balancing network 40 by operation of the control relay R4 when the carrier terminal CT is receiving carrier oscillations on the reverting frequency f_3 (185 kilocycles) in the manner which will be described later in connection with the description of operation of the whole system.

The alternate balancing network 44 may comprise a single terminating resistor or other simple network such as to provide suitable unbalance of the hybrid coil 39 so that voice signals may be transmitted through the latter from the receiving circuit 38 to the transmitting circuit 36 on a reverting call, with as little loss and distortion as possible, and to provide substantially the same degree of loss for all frequencies in the voice frequency band. The normal balancing network 40, on the other hand, should comprise a more elaborate network suitable for providing adequate balance over the voice frequency range of any one of the different impedance lines which may be connected to the terminal by the associated central office CO, and in particular is designed to provide the best possible balance on long distance central office calls.

The transmitting circuit 36 of the carrier terminal CT includes in order between the hybrid

coil 39 and the coupler device 10, reading from left to right, a voice frequency amplifier and a modulator with an associated oscillator for supplying thereto carrier oscillations of the frequency f_1 (165 kilocycles), represented by the box 45; and an automatic voice frequency volume limiter 46 which may be of any of the well-known types, associated with the voice frequency amplifier for controlling the gain of the latter so as to limit the volume level of the voice frequency signals applied to the modulator to that value which will provide adequate modulation on long distance incoming calls from outside subscribers while preventing overloading of the modulator on incoming calls from nearby outside subscribers or subscriber stations on the power line; a high frequency amplifier 47 for amplifying the waves in the output of the modulator; and the transmitting band-pass filter 48 designed to selectively transmit one or both signal side-band products as well as the unmodulated carrier component of the frequency f_1 (165 kilocycles) produced in the output of the modulator. The voice frequency amplifier, modulator and carrier oscillator included in the box 45 may comprise separate elements or may be combined in a single multigrid electron discharge tube as is well-known in the art.

The receiving circuit 37 in the carrier terminal CT includes in order between the coupler device 10 and the hybrid coil 39, reading from right to left, the receiving band-pass filter 49 adapted for selectively transmitting the speech-modulated and unmodulated carrier waves of the normal frequency f_2 (195 kilocycles) received over the line from the subscriber carrier stations; the high frequency amplifier 50, which may comprise one or more vacuum tube amplifying stages with associated interstage and output band-pass filters for tuning it over the frequency band transmitted by the band-pass filter 49; an automatic volume control circuit 51 of any of the well-known types associated with this amplifier for controlling its gain so as to compensate for variations in the amplitude levels of the applied carrier signals due to loss variations on the power line 1; and the demodulator 52 for demodulating the applied high frequency modulated carrier waves to voice frequencies, which demodulator may be of any of the well-known types, such as one comprising copper-oxide or crystal rectifiers.

The receiving circuit 38 includes in order between the coupler device 10 and the hybrid coil 39, reading from right to left, the receiving band-pass filter 53 adapted for selectively transmitting the speech modulated and unmodulated carrier waves of the reverting frequency f_3 (185 kilocycles) which may be received over the line 1 from the subscriber carrier stations; a high frequency amplifier 54, which may comprise one or more vacuum tube stages tuned to amplify efficiently the band of frequencies transmitted by the band-pass filter 53; an automatic volume control 55, similar to the automatic volume control circuit 51, associated with amplifier 54; and the demodulator 56, similar to the demodulator 52 in the receiving circuit 37, for demodulating the applied high frequency signal waves to voice frequencies.

The output of the receiving circuit 38 is normally disabled due to the normal break in the circuit connections between the demodulator 56 and the hybrid coil 39 provided by one set of normally open switching contacts of the unoperated relay R4. The switching relay R3 is con-

connected directly to the demodulator 52 in the receiving circuit 37 so as to be operated in response to the rectified output of that demodulator when carrier waves of the frequency f_2 (195 kilocycles) are applied to its input, but the connection of the switching relay R4 to the output of the demodulator 56 in the receiving circuit 38 is normally broken through normally open switching contacts on relay R3, so that relay R4 can only be operated by the rectified output of the demodulator 56 in response to the applied carrier waves of the frequency f_3 (185 kilocycles) if the relay R3 is also operated.

The carrier terminal CT includes two other control relays designated R5 and R6, respectively. As shown in Fig. 1, the relay R5 is connected through the full-wave rectifier bridge 57 between ground and one side of the voice frequency line 41 and ground in front of the normal disabling point in that line, so as to be operatively responsive to ringing signals, say, of 20 cycles received over that line from the central office CO, and rectified in rectifier 57. Alternatively, the relay R5 may be bridged through full-wave rectifier bridge 57 across the voice frequency line 41. The relay R6, which is a slow-release relay, is normally unoperated and is adapted to be operatively energized either from battery 58 through normally closed switching contacts on the relay R5, when that relay is unoperated, and operated switching contacts on the relay R3 when the latter relay is operated, or from battery 59 through normally closed contacts on relay R5 with that relay unoperated, and operated contacts on the relay R4 when the latter relay is operated.

The transmitting circuit 36 in the carrier terminal CT is normally inoperative to transmit the carrier frequency f_1 (165 kilocycles) to the line 1, due to the normal disablement of the energizing circuit from battery 60 or battery 61 for the voice frequency amplifier, carrier oscillator and modulator within the box 45 and the high frequency amplifier 47 as provided by normally open switching contacts of the unoperated control relays R5 and R6, respectively.

The operation of the system of the invention will now be described with reference to Figs. 1 and 2.

Central office call originated by a carrier subscriber

In the idle condition of each of the subscriber stations A, B, C . . . associated with one carrier channel on the power line 1, the receiving circuit 16 is operative, but the transmitting circuit 15 is disabled because of the disconnection of the power supply (battery 31) from the transmitting modulator-oscillator 20 and the high frequency amplifier 21 in the latter circuit due to the open condition of the associated switching contacts of hook switch 29 with the handset 18 on the hook. Also, in the idle condition of each subscriber's station, the 195-kilocycle control crystal Y1 is connected through normally closed contacts of unoperated control relay R2 in the frequency determining circuit of the carrier oscillator associated with the transmitting modulator (box 20) in transmitting circuit 15, so that this oscillator, when energized, will be conditioned to supply carrier oscillations of the normal frequency f_2 (195 kilocycles) to the associated modulator, and the 185-kilocycle control crystal Y2 is disconnected from that frequency determining cir-

cuit due to the normal open condition of other contacts of the unoperated control relay R2.

When a telephone subscriber associated with one carrier channel on the power line 1, for example, the subscriber at station A, wishes to call a subscriber outside the system in which the former is assigned, through the central office CO, the former lifts his handset 18 off the switchhook, which closes contacts in the hook switch 29 causing the transmitting modulator-oscillator 20 and the high frequency amplifier 21 to be energized from power supply battery 31, and the energizing circuit for relay R2 from battery 31 through hook switch 29 to be disabled by other open contacts of the latter. The unmodulated carrier component of frequency f_2 (195 kilocycles) appearing in the output of the energized modulator-oscillator 20 will be amplified in the high frequency amplifier 21 and will pass through the transmitting band-pass filter 22, the plug-in resistance pad 23 and coupler device 9 to the power line over which it will be transmitted to the carrier terminal station CT.

At the carrier terminal CT, the received carrier wave of frequency f_2 (195 kilocycles) will pass through the coupler device 10 and will be selected by the receiving band-pass filter 49 in the receiving circuit 37. The selected carrier of frequency f_2 (195 kilocycles) will be amplified in the high frequency amplifier 50 and its amplitude level automatically regulated to the desired constant value by the associated automatic volume control circuit 51. The amplified carrier will be rectified in demodulator 52, and the rectified current in the output of the demodulator 52 will operate the control relay R3 causing all of its switching contacts to be closed. The closed left-hand switching contacts of relay R3 will close the voice frequency line loop 41 to the central office CO causing signaling or automatic control equipment (not shown) in that office to be operated. This will either cause the central office to return dial tone, or, in a manual office, will cause the operator to connect to the line 41.

The closure of the right-hand front contacts of relay R3 will complete the connection of control relay R4 to the output of the demodulator 56 in receiving circuit 38 for reasons which will be apparent from the later discussion. The closure of the right-hand back contacts of relay R3 will cause relay R6 to be operated from battery 58. The operation of relay R6 will break the connection of rectifier 57 and associated control relay R5 with the voice frequency line 41 to the central office CO. The operation of relay R6 will also cause the transmission apparatus (voice frequency amplifier-oscillator-modulator 45 and high frequency amplifier 47) in the transmitting circuit 36 to be energized from battery 61, causing an amplified carrier wave of the frequency f_1 (165 kilocycles) to be transmitted through high frequency amplifier 47, band filter 48 and coupler device 13 to the power line 1 and out over that line to all of the subscriber stations.

At each of the subscriber stations A, B, C . . . the received carrier of the frequency f_1 (165 kilocycles) will be transmitted through the coupler device 9, plug-in pad 24, receiving band filter 25 and high frequency amplifier 26 to the demodulator 28, and the rectified output of the latter will cause the operation of the associated control relay R1. In every station, except that of the calling subscriber (at station A) whose handset 18 is off the hook thus breaking the energizing circuit for relay R2 from battery 31 at

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that station, the operation of the relay R1 by the received continuous carrier of frequency f_1 will cause the associated control relay R2 to be operated from battery 31, and then locked operated from that battery through the operated right-hand front contacts of the latter relay. The closure of the left-hand contacts of operated relay R2 will cause the busy signal lamp 35 at the station to be lighted from battery 62. Thus, all other subscriber stations B, C . . . are informed that the line 1 is being utilized on a call.

In a dial area, the dial tone automatically transmitted over the voice frequency line 41 from the central office CO to the carrier terminal CT in response to the closure of the voice frequency line 41 at that terminal by relay R3 controlled by the rectified carrier of frequency f_2 from the calling station A, is applied by hybrid coil 39 to the input of the oscillator-modulator 45 to modulate the outgoing carrier of frequency f_1 (165 kilocycles) supplied to line 1. In a manual area, speech from the operator at the central office CO is transmitted over the voice frequency line 41 and applied through hybrid coil 39 to the oscillator-modulator 45 to modulate the outgoing carrier of frequency f_1 . At the calling station A, the dial tone or operator's speech signals modulated on the carrier f_1 will pass through the coupler device 9 and receiving circuit 16 at the calling subscriber's station (station A) to the demodulator 28 in which they will be demodulated to voice frequencies and will be heard by the calling subscriber in his telephone receiver 19.

The subscriber at the calling station A then talks into his transmitter to tell the central office operator to which outside subscriber's station he wishes to be connected, or operates his calling dial 32 in the usual manner to dial the number of the station being called. In the former case, A's signals will be combined in his modulator-oscillator 20 with the carrier oscillations of the normal frequency f_2 (195 kilocycles) and the modulated carrier will be transmitted out over the line 1 to the demodulator 52 in the receiving circuit 37 of the carrier terminal station CT as previously described for the unmodulated carrier. The demodulated voice signals of A in the output of the demodulator 52 will pass through the hybrid coil 39 and voice frequency line 41 (maintained closed by the continued operation of relay R3) to the operator in the central office CO.

When the subscriber at the calling station A dials the number to be called on his dialing device 32, this operation causes the transmitted carrier of frequency f_2 (195 kilocycles) to be interrupted in accordance with the digits dialed. The control relay R3 associated with the demodulator 52 in the receiving circuit 37 at the carrier terminal CT follows the received 195 kilocycle pulses, the corresponding closures and releases of its left-hand contacts, operating to relay the dialing pulses on to the central office over the voice frequency line 41 where they direct the switches (not shown) in the selection of the called party.

The central office operator or the machine switching equipment in the central office calls the called subscriber on the associated network in the usual manner, and sets up a talking circuit between the called subscriber and calling subscriber A on the power line through the central office CO, so that they can converse with each other.

The voice signals of the called outside subscriber will be transmitted at voice frequencies

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from the central office CO over the voice frequency line 41 to the carrier terminal station CT and will be impressed by the hybrid coil 39 on the transmitting circuit 36 at that terminal. In that circuit, the called subscriber's voice signals will be amplified and then modulated in the device 45, which is maintained energized by the continued operation of relay R6, on the carrier oscillations of the frequency f_1 (165 kilocycles), and the modulated carrier wave will be amplified in the high frequency amplifier 47 and passed out through the transmitting band filter 48 and the coupler device 10 to the power line over which it will be transmitted to the calling subscriber's station A. At the latter station, the voice-modulated carrier wave of frequency f_1 (165 kilocycles) will pass through the coupler device 9 and the plug-in resistance pad 24 and will be selected by the receiving band filter 25 in the receiving circuit 16 at that station. The selected signals of the outside subscriber will be amplified in amplifier 26, demodulated in the demodulator 28 and will be heard by the subscriber A in his telephone receiver 19.

The voice signals of the calling subscriber at station A will be transmitted from his station as modulations of his normal carrier frequency f_2 (195 kilocycles) over the line 1 to the demodulator 52 in the receiving circuit 37 of the carrier terminal CT in the manner previously described for the unmodulated carrier of that frequency. A's voice signals in the output of the demodulator will be divided by the hybrid coil 39 between the voice frequency line 41 and the transmitting circuit 36 of the carrier terminal. The portion entering voice frequency line 41 will pass over that line through the central office CO to the called subscriber's line. The other portion of A's voice signals will be modulated in the transmitting circuit 16 on the transmitted carrier wave of the frequency f_1 (165 kilocycles), and the resulting voice modulated carrier will be returned over the power line 1 to the calling subscriber's station where it will be selected, amplified, demodulated and heard in its receiver 19 as side tone.

At the end of the call, the subscriber at station A will hang his handset 18 up on hook switch 29 causing the opening of switching contacts in the latter to disconnect the power supply 31 from the modulator-oscillator 20 and high frequency amplifier 21. This will stop the transmission of the carrier frequency f_2 (195 kilocycles) over the line 1. At the carrier terminal CT, the cessation of the received carrier f_2 will cause the relay R3 to release to open the voice frequency line closure at the terminal, and the subsequent release of the relay R6 will remove the energizing power supply from the apparatus in the transmitting circuit 36 to stop the transmission of the outgoing carrier frequency f_1 and will return the other circuits in the carrier terminal to normal.

Operation on a central office call originated through the central office

On a central office call originated through the central office CO to one of the subscriber stations A, B, C . . . on the power line 1, the operator or machine switching equipment in that office applies coded ringing current, say of 20 cycles per second, between one side of the voice frequency line 41 and ground. At the carrier terminal station CT, this current is rectified in the rectifier 57 causing the operation of the associated relay R5, while the supply of ringing current continues, to

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connect an energizing circuit from battery 60 to the voice frequency amplifier oscillator-modulator 45 and the high frequency amplifier 47 in the transmitting circuit 36 at the terminal conditioning that transmitting circuit to send out amplified carrier oscillations of the frequency f_1 (165 kilocycles) through the coupler device 10 to the line; and also to connect the voice frequency line 41 to the input of the oscillator-modulator 45 so that the coded 20-cycle ringing signals from the central office will be supplied to the modulator to modulate the carrier of frequency f_1 (165 kilocycles) transmitted out over the line 1 during the duration of the applied ringing tone. The carrier of frequency f_1 (165 kilocycles) modulated with the 20-cycle ringing signals is diverted through the coupler devices 9 into the receiving circuit 16 of all subscribers' stations A, B, C . . . on the power line 1. In the receiving circuit 16 at each subscriber's station this ringing signal-modulated carrier f_1 (165 kilocycles) will be passed through the pad 24 and the receiving band filter 25, amplified in amplifier 26 and demodulated in demodulator 28 causing the operation of the associated control relay R1 at the 20-cycle rate, which in turn will cause the voice frequency ringer 34 at the station to be operated at the 20-cycle coded rate. A circuit for operating the ringer 34 is closed by charging the condenser 63 in series with the ringer 34 when relay R1 is operated. The condenser 63 is discharged through the ringer 34 during the periods in which the relay R1 is released.

The subscriber at the called station on the power line, recognizing his coded ring, answers by removing the handset 18 from the hook switch 29 at his station. This will cause the modulator-oscillator 20 and high frequency amplifier 21 in his transmitting circuit 15 to be energized from battery 31 through operated switching contacts on the hook switch 29, and the operating circuit for the control relay R2 from battery 31 to be opened by the opening of other associated switching contacts on the hook switch 29. If the relay R2 is operated on the ringing current supplied to the relay through its locking contact, so as to connect the 185-kilocycle crystal Y2 in the frequency-determining circuit of the modulator-oscillator 20 in place of the normal 195-kilocycle crystal Y1, the reverting carrier frequency f_3 (185 kilocycles) may be momentarily applied to the power line through the transmitting circuit 15 and coupler device 9. This momentary spurt of carrier frequency f_3 (185 kilocycles) will have no effect on the switching circuits at the carrier terminal CT inasmuch as the switching relay R4 associated with the demodulator 56 in the receiving circuit 38 of that terminal which selects that frequency, cannot be operated due to the break in its energizing circuit through the normally open switching contacts on the control relay R3. The latter will not be operated in the absence of the supply of the normal carrier frequency f_2 (195 kilocycles) to the terminal. The control relay R2 at the called subscriber's station releases on the next half cycle of ringing current and cannot again reoperate because its original operating path has now been opened by operation of the hook switch 29. Therefore, carrier of the normal frequency f_2 (195 kilocycles) will be applied to the line 1 from the output of the oscillator-modulator 20 in transmitting circuit 15 of the called subscriber's station.

At the carrier terminal CT, this carrier wave of frequency f_2 (195 kilocycles) will be diverted from

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the line through the coupler device 10 into the carrier terminal CT and will be selected by the filter 49 in the receiving circuit 37 therein. The selected carrier f_2 will be amplified in amplifier 50 and rectified in demodulator 52 causing the operation of the associated relay R3 in the manner previously described to provide a closure of the voice frequency line 41 to the central office CO, and to operate the control relay R6. The operation of the relay R6 causes the modulator-oscillator and voice frequency amplifier apparatus (box 45) in the transmitting circuit 36 at the terminal to be energized from battery 61 so that a carrier wave of the frequency f_1 (165 kilocycles) is sent out from that circuit through the coupler device 10 to the line 1. In the manner which has been previously described, at each of the subscribers' stations A, B, C . . . except the called subscriber's station, the received carrier of frequency f_1 will operate the relay R2, which in turn will cause the busy lamp 35 at the station to be lighted.

The closure of the voice frequency line 41 at the carrier terminal CT in response to the operation of the control relay R3 by the rectified carrier of the normal frequency f_2 (195 kilocycles) will trip the ringing from the central office. The outside subscriber and the called carrier subscriber then can communicate with each other over the talking paths which are set up through the central office CO.

When the call is completed, and the called subscriber on the power line hangs up his handset on the hook, his carrier transmitting apparatus is deenergized by the opening of certain switching contacts on the hook switch 29 breaking the energizing circuit from battery 31, and transmission of the normal carrier frequency f_2 (195 kilocycles) over the power line 1 ceases. This causes the relay R3 to be released at the carrier terminal CT. The release of the relay R3 in turn causes the release of the relay R6, and the resultant opening of the voice frequency line 41 to the central office CO transmits a disconnect signal to that office.

The relay R6 at the carrier terminal CT is a slow-release relay. During the releasing time of this relay, the relay R2 in the called subscriber's station will momentarily operate to light the busy lamp 35 at his station. With the release of the relay R6 at the carrier terminal CT, the apparatus in the transmitting circuit at that terminal is deenergized so that the carrier f_1 (165 kilocycles) is removed from the line 1. Therefore, the operated R1 and R2 relays in all of the subscribers' stations A, B, C . . . will release and the busy signal lamps at these stations will be extinguished.

If a subscriber at one of the stations A, B, C . . . on the power line, when connected through a common battery manual central office should flash his switchhook, the circuit operation will be as follows: On the first hang-up of his handset 18, the carrier transmitting apparatus at his station will be deenergized. This will cause the relay R3 at the carrier terminal CT to be released so as to disconnect operating battery from the relay R6 at that terminal. The relay R6, however, is slow releasing. Therefore, the carrier apparatus in the transmitting circuit 36 at the carrier terminal CT will be maintained energized to maintain transmission of the carrier f_1 (165 kilocycles) over the line 1 for a long enough time to permit the relay R2 at the subscriber's station to be operated and locked so as to revert the transmitting frequency of the subscriber's station from f_2 (195 kilocycles) to f_3 (185 kilocycles) due to the substitution of

the crystal Y2 for the crystal Y1 in the frequency-determining circuit of the carrier oscillator at that station. This, however, will not result in the operation of the relay R4 at the carrier terminal CT by the received reverting frequency f_3 , because the relay R3 at that terminal is already released and its contacts provide a break in the energizing circuit for relay R4 from the demodulator 56. When the relay R3 released, it also opened the line loop 41 to the central office CO giving a signal to the operator at that office. This condition will be maintained until the relay R6 at the carrier terminal completely releases to deenergize the carrier transmitter at the terminal and remove the outgoing carrier f_1 (165 kilocycles) from the line 1 thus releasing the relay R2 at the carrier subscriber's station. The release of the relay R2 at the subscriber's station changes the carrier frequency transmitted from that station from f_3 (185 kilocycles) to f_2 (195 kilocycles) and this frequency is transmitted provided the switchhook is again operated. This causes the relay R3 at the carrier terminal CT to be again operated to close the loop to the central office CO and thus signal the operator. This operation should tend to make all flashes from the subscriber slow in character.

Reverting call-between carrier subscribers in the same channel on the power line

To make an inter-party line or reverting call, say to a subscriber at station B, the subscriber at station A will remove his handset 18 from the hook switch 29 causing the transmission apparatus 20 and 21 in his transmitting circuit 15 to be energized so as to transmit his normal transmitting carrier f_2 (kilocycles) to the line 1. The subscriber will then either dial or pass the listed number to the operator at the central office CO by talking in his transmitter to modulate his transmitted carrier of frequency f_2 (195 kilocycles) in the manner previously described in connection with a central office call originated by the subscriber.

The calling subscriber at station A will then hang up, and the operator or machine switching equipment at the central office CO will apply coded 20-cycle ringing current to the voice frequency line 41 which, in the manner previously described for a central office call, will cause the carrier transmitter at the carrier terminal CT to be energized to send carrier of the frequency f_1 (165 kilocycles) out over the line modulated with the coded 20-cycle ringing current from the central office. The carrier f_1 modulated with 20-cycle ringing current will be received and detected in the receiving circuits of all of the subscribers' sets on the line 1 causing the operation of the control relay R1 at all of these stations to produce operation of the ringer 34 in accordance with the code as previously described.

When the called subscriber at station B answers his coded ring by removing his handset 18 from the switchhook 29, the carrier apparatus in his transmitting circuit 15 is energized so as to send out his normal carrier frequency f_2 (195 kilocycles) to the line 1 and over that line to the carrier terminal CT where it will cause the operation of the relay R3 associated with the demodulator 52 in the receiving circuit 31 which selects the normal carrier frequency. The closure of the line loop 41 to the central office CO at the carrier terminal CT by operation of the relay R3 operates to trip the ringing from that office. The operation of the relay R3 at the carrier terminal also causes the operation of the

relay R6 which energizes the carrier apparatus in the transmitting circuit 36 at that terminal so that the carrier frequency f_1 (165 kilocycles) is sent out through the coupler device 10 over the line 1. During the ringing phase of the call, the signaling operations are as described above for a central office call originated through the central office CO.

When the calling subscriber at station A notes that the ringing has stopped and that the called party has answered, indicated by the lighting up of the former's busy signal lamp 35, the calling subscriber at station A again removes his handset 18 from the hook switch 29 causing the oscillator-modulator 20 and high frequency amplifier 21 in the transmitting circuit 15 at his station to be energized from battery 31 through operated switching contacts on the hook switch. At this time, the relay R2 at the calling subscriber's station is operated and locked from battery 31 through its operated right-hand front contact due to the previous operation of the relay R1 in response to the rectified continuous carrier of the frequency f_1 (165 kilocycles) received over the line 1 from the carrier terminal CT. The operated relay R2 through its right-hand back contacts causes the 195-kilocycle crystal Y1 to be removed from the frequency determining circuit of the modulator-oscillator 20 and the 185-kilocycle crystal Y2 to be substituted therefor in that circuit. Thus, the energized transmitting circuit 15 at the subscriber's station A will send out continuously a carrier wave of the reverting frequency f_3 (185 kilocycles) while the handset 18 remains off the hook. This carrier wave will be amplified in the high frequency amplifier 21 and will pass through the transmitting band filter 22, plug-in pad 23 and coupler device 9 to the line 1 over which it will be transmitted to the carrier terminal CT.

At the carrier terminal CT, the received carrier wave of the frequency f_3 (185 kilocycles) will pass through the coupler device 10 and will be selected by the receiving band filter 53 in the receiving circuit 38. The selected carrier will be amplified by the amplifier 54 and be rectified in the demodulator 56. The rectified output of the demodulator 56 will cause the operation of the associated relay R4 which can be operated at this time because the relay R3 which controls the energizing circuit of the latter relay has been previously operated in response to the rectified carrier wave of the frequency f_2 (195 kilocycles) transmitted from the called subscriber's station B, the two relays R3 and R4 providing joint holding paths for the called and calling subscribers, respectively. Each relay R3 and R4 by operating provides a separate closure of the voice frequency loop 41 to the central office CO and holds relay R6 operated from batteries 58 and 59, respectively. The operation of the relay R4 also closes the connection from the output of the demodulator 56 in the receiving circuit 38 to the hybrid coil 39, and connects the auxiliary balancing network 44 suitable for use on a reverting call to the network terminals of hybrid coil 39 in place of the normal balancing network 40 used on central office calls. Thus a direct talking connection between the calling subscriber A and the called subscriber B is provided through the carrier terminal CT.

The calling subscriber at station A by talking into his transmitter 17 modulates the carrier of the reverting frequency f_3 (185 kilocycles) in his oscillator-modulator 20, and the voice-modulated

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carrier wave of this frequency in amplified form is transmitted through the transmitting circuit 15 and the coupling device 9 to the power line 1 and over that line to the demodulator 56 in the receiving circuit 38 at the carrier terminal CT in the manner previously described for the unmodulated carrier wave of that frequency. The demodulated voice signals of subscriber A in the output of the demodulator 56 will be transmitted through the partially unbalanced hybrid coil 39 to the transmitting circuit 36 at the carrier terminal CT, in which it will be remodulated on the carrier frequency f_1 (165 kilocycles) in the modulator-oscillator 45 held energized by operated relay R6. The voice-modulated carrier wave of the frequency f_1 will then be amplified in the amplifier 47 and will pass out through the transmitting band filter 48 and the coupler device 10 to the power line 1 over which it will be transmitted to subscriber station B. At the subscriber station B, the voice modulated carrier of frequency f_1 will be diverted through the coupler device 9 and equalizer pad 24 into the receiving circuit 16 of the station in which it will be selected by the receiving band filter 25, amplified by the amplifier 26 and passed to the demodulator 28 in which A's voice signals will be demodulated and will be heard by subscriber B in his receiver 13.

Similarly, the speech signals from the called subscriber B at his station modulates a carrier wave of the normal frequency f_2 (195 kilocycles) in the transmitting oscillator-modulator 20, and the modulated carrier wave will be amplified by high frequency amplifier 21 and transmitted through transmitting band filter 22, plug-in pad 23 and coupler device 9 to the power line 1 over which it will be transmitted to the carrier terminal CT. At the carrier terminal CT, the carrier wave of frequency f_2 (195 kilocycles) modulated with subscriber B's voice signals, will be diverted through the coupler device 10 into the receiving circuit 37 in which it will be selected by the band filter 49, amplified by the amplifier 50 and demodulated to voice frequencies in the demodulator 52. B's voice signals will pass from the output of demodulator 52 through the partially unbalanced hybrid coil 39 to the transmitting circuit 36 of the carrier terminal in which they will be remodulated on the transmitted carrier wave of the frequency f_1 (165 kilocycles) in the oscillator-modulator 45, and the voice-modulated carrier will be passed out in the amplified form to the power line 1 over which it will be transmitted to the calling station A. At the subscriber's station A, the carrier wave of the frequency f_1 modulated with B's voice signals will be diverted through the coupler device 9 and equalizer pad 24 into the receiving circuit 16 in which it will be selected by filter 25, amplified by amplifier 26 and demodulated by demodulator 28, and the demodulated voice signals of B will be heard by subscriber A in his receiver 19.

When the call between subscribers' stations A and B is completed, both subscribers will hang up their handsets 18 which will automatically deenergize the modulator-oscillator 20 and high frequency amplifier 21 in each transmitting circuit 15, stopping the transmission from the station of the carrier oscillations of the frequencies f_2 and f_1 , respectively. The cessation in the supply of the carrier waves of the frequencies f_2 and f_1 at the carrier terminal CT will result in the release of the switching relays R3, R4 and R6 at that terminal, returning the circuit at that

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terminal to the normal condition shown with the carrier transmitter deenergized and the normal balancing network 40 associated with the hybrid coil 39. The deenergization of the transmitting circuit at the carrier terminal cutting off the transmission of the carrier frequency f_1 (165 kilocycles) will result in the release of the switching relays R1 at subscribers' stations A and B. The consequent release of relay R2 at the calling subscriber's station A will extinguish the busy signal lamp 35 and will cause the crystal Y2 to be disconnected from the frequency-determining circuit of the modulator-oscillator 20 and the crystal Y1 to be substituted therefor so as to revert the modulator-oscillator 20 at that station to its normal tuning (f_2 —195 kilocycles).

If, during a reverting or central office call, a third carrier subscriber removes his handset 18 from the switchhook, the latter's transmitter will send out carrier oscillations of the reverting frequency f_3 (185 kilocycles) over the line 1 because of the presence of carrier oscillations f_1 on that line, holding the relay R2 at the third subscriber's station locked operated. This will cause beat notes and distortion of the speech between the other parties engaged in the call, since the transmitted carrier frequency of the third subscriber will in most cases be slightly different from that of the subscriber previously using the carrier frequency f_3 . In spite of this distortion interference, transmission will probably be sufficiently good to provide a means for explaining the emergency condition which would require this type of break-in by a certain subscriber. Such a break-in will not release the circuit, and transmission will return to normal as soon as the third party hangs up. The operator can always break in on either a central office or a reverting call if required by an emergency.

The invention has been described as applied to only one carrier channel on the power line 1, but it is apparent that a number of different channels may be operated on the same line by the assignment of three different carrier frequencies for each channel, in which case separate carrier terminals associated with the same or different central switching offices would be employed for each individual channel. The apparatus and circuit arrangements at the subscribers' stations and carrier terminals associated with the additional carrier channels may be identical with those in the system as described above and illustrated in the drawings, except for the changes required in the carrier oscillators and band filters due to the use of different carrier frequencies for the several channels. Other changes in the circuits illustrated and described which are within the spirit and the scope of the invention will occur to persons skilled in the art.

What is claimed is:

1. In a carrier communication system, a transmission medium and stations coupled to said medium, including a carrier terminal station and a plurality of carrier subscriber stations, said carrier terminal station including a transmitter for transmitting communication signals to said medium on a carrier wave of one frequency and two receivers for respectively detecting communication signals received over said medium on a carrier wave of a second frequency and a carrier wave of a third frequency, each of said carrier subscriber stations including a transmitter normally conditioned for transmitting to said medium on a carrier wave of said second frequency only, switching means responsive to applied car-

rier waves of said one frequency received over said medium from said carrier terminal station for conditioning the transmitter at the local subscriber station for transmitting to said medium on a carrier wave of said third frequency only and other switching means for preventing operation of the first switching means if said local subscriber station is transmitting to said medium on a carrier wave of said second frequency at the time of arrival of a carrier wave of said one frequency thereat over said medium.

2. In a carrier communication system, a transmission medium and a plurality of stations coupled to said medium, including a carrier terminal station and a plurality of carrier subscriber stations, said carrier terminal station including a transmitter for transmitting communication signals on carrier waves of one frequency to said medium for transmission thereover to all of said carrier subscriber stations and two receivers for respectively detecting communication signals received over said medium on a carrier wave of a second and a third frequency, each of said carrier subscriber stations including a transmitter normally conditioned for operation under control of the subscriber at the station to transmit communication signals to said medium on a carrier wave of said second frequency only, switching means responsive to carrier waves of said one frequency received over said medium to condition the transmitter at the local subscriber station for transmitting to said medium on a carrier wave of said third frequency only and a second switching means operating to disable the first switching means only if the transmitter at the station is made operative to transmit carrier waves of said second carrier frequency to said medium prior to arrival of the carrier waves of said one frequency at the subscriber station.

3. In combination in a carrier communication system, a transmission medium and stations including a carrier terminal station and a plurality of carrier subscriber stations, coupled to said medium, said carrier terminal station including a transmitter for sending communication signals on a carrier wave of one frequency out over said medium to said subscriber stations, and two receivers for detecting communication signals received over said medium from said subscriber stations on a carrier wave of a second frequency and a third frequency, respectively, each of said subscriber stations including a receiver for detecting communication signals received over said medium on a carrier wave of said one frequency and a transmitter for transmitting communication signals over said medium to said carrier terminal either on a carrier wave of said second frequency or a carrier wave of said third frequency, the latter transmitter being normally conditioned for operation under control of the local subscriber to transmit on a carrier wave of said second frequency only, relay switching means responsive to the wave energy in the output of the local receiver when a carrier wave of said one frequency is received at the station over said medium for conditioning the transmitter at the station for operation under control of the local subscriber to transmit over said medium on a carrier wave of said third frequency only and other switching means controlled by the local subscriber when he seizes control of the local transmitter, only in the absence of operation of the first switching means by carrier wave energy of said one frequency previously received at the station over said medium, for preventing

operation of said first switching means in response to carrier wave energy of said one frequency subsequently received over said medium.

4. In a carrier communication system, a transmission line, stations coupled to said line including a different group of carrier subscriber stations and an individual carrier terminal station for each carrier channel thereon and a central switching office associated with the carrier terminal stations, the individual carrier terminal station for one carrier channel including a normally de-energized signal transmitter which, when energized, is operative to send out communication signals on a carrier wave of one frequency over said line to said subscriber stations and two receivers for detecting communication signals received over said line on a carrier wave of a second frequency or on a carrier wave of a third frequency, respectively, each of the subscriber stations for said one carrier channel including a receiver for detecting communication signals received over said line on a carrier wave of said one frequency, a transmitter normally adapted under control of the subscriber at the station for sending out communication signals over said line on a carrier wave of said second frequency only, relay switching means responsive to the wave output of the local receiver when carrier wave energy of said one frequency is received at the station over said line to condition the transmitter at the station for operation under control of the subscriber thereat to send out communication signals over said line on a carrier wave of said third frequency and means also under control of the subscriber at the station for effectively disabling said switching means if he causes the transmitter at the station to be rendered operative prior to the arrival at the station over said line of carrier waves of said one frequency.

5. The system of claim 4 in which said carrier terminal station for said one carrier channel also includes means responsive to ringing signals received from said central office or carrier waves of said second frequency received over said line from one of said subscriber stations for said one channel for energizing the local transmitter means responsive to carrier waves of said third frequency received over said line for holding the transmitter in the energized condition.

6. In a carrier communication system, a main transmission line, a plurality of stations coupled to said line including an individual carrier terminal station and a different group of carrier subscriber stations associated with each carrier channel on said line, a central switching office for said stations on said line connected thereto through the carrier terminal stations, and adapted also for connecting outside subscriber communications stations on other lines in communication relation with the carrier subscriber stations in each group on said main line through its individual carrier terminal station, each of the carrier subscriber stations in the group assigned to one carrier channel including a receiver operative to detect communication signals received at the station over said main line modulated on a carrier wave of a frequency f_1 , a transmitter normally conditioned under control of the subscriber at the station for sending out communication signals modulated on a carrier wave of a second frequency f_2 over said main line to the carrier terminal station for that channel on calls between that station and said central office or an outside subscriber station

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connected through said office, switching means responsive to a continuous carrier wave of the frequency f_1 received over said main line from the latter carrier terminal station only if the transmitter at the subscriber station at the time is not transmitting to said main line on a carrier wave of the frequency f_2 , to condition that transmitter for sending out under control of the local subscriber communication signals modulated on a carrier wave of a third frequency over said main line, for a reverting call between the local subscriber station and another carrier subscriber station in the same group on the main line initiated at the local station, the carrier terminal station for said one carrier channel including a transmitter operative under control of call signals from said central office or in response to a carrier wave of the frequency f_2 received over said main line from one of the carrier subscriber stations associated with said one channel, to send out a carrier wave of the frequency f_1 over said main line to the carrier subscriber stations, two receivers for respectively selectively receiving the carrier waves of the frequency f_2 and f_3 incoming over said main line and for demodulating the communication signals therefrom and means to supply the demodulated signals to said central office and to the transmitter in the carrier terminal station for remodulation on the carrier wave of the frequency f_1 sent out thereby over said line to said carrier subscriber stations.

7. The system of claim 6, in which said carrier terminal station for said one carrier channel includes means for causing the signal output of the receiver thereof for selectively receiving carrier waves of the frequency f_3 to be connected to said central office and to the transmitter at that station only when carrier waves of both frequencies f_2 and f_3 are being received over said line at said carrier terminal station.

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8. The system of claim 6, in which said central office is connected to the transmitter and two receivers at the carrier terminal station for said one carrier channel through a voice frequency line, a hybrid coil and an associated normal line balancing network suitable for providing adequate balance of any of said other lines which may be connected in communication relation through the central office with the carrier subscriber stations on said main line, and said carrier terminal station for said one channel includes switching means responsive to a carrier wave of said third frequency received thereat over said main line for substituting an auxiliary balancing network for said normal network, said auxiliary balancing network being suitable for providing a desired amount of unbalance of said hybrid coil so as to enable a sufficient amount of the demodulated signal energy output of said receiver for selectively receiving carrier waves of said frequency f_3 to be transmitted through said hybrid coil to the transmitter at the carrier terminal station on a reverting call.

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